(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 141 640**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **84307463.4**

(22) Date of filing: **30.10.84**

(51) Int. Cl.⁴: **A 61 F 2/60**

(30) Priority: **31.10.83 GB 8329018**

(43) Date of publication of application: **15.05.85**
Bulletin 85/20

(84) Designated Contracting States: **DE FR NL**

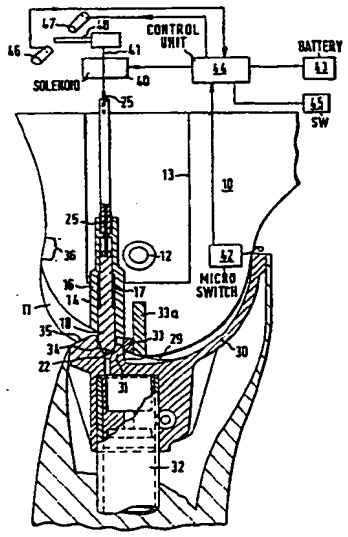
(71) Applicant: **J.E. HANGER & COMPANY LIMITED, Roehampton Lane, Roehampton London SW15 5PL (GB)**

(72) Inventor: **Brown, David John, 13 Luccombe Road Upper Shirley, Southampton Hampshire (GB)**

(74) Representative: **Cole, Paul Gilbert et al, Hughes Clark Byrne & Parker 63 Lincoln's Inn Fields, London WC2A 3JU (GB)**

(54) Electrically released prosthetic joint.

(57) A knee joint having first and second members (10, 30) pivoted together for flexion and extendion has a spring loaded plunger (18) in the knee member (10) that latches into a socket (34) in the knee housing (30) to hold the knee in its extended position. A solenoid (40) operatively connected to the plunger (18) unlatches the plunger (18) from the socket (34) and a sensor (46, 47) detects unlatching movement of the solenoid (40). A circuit (44) responds to activation of operating switch (45) and to the sensor (46, 47) to reduce the current through solenoid (40) to a holding value when unlatching occurs within a set time after operation of switch (45) and in the absence of movement substantially de-energises the solenoid (40). The solenoid is reliable in operation and failure to release does not bring about undue power drain.



EP 0 141 640 A1

ELECTRICALLY RELEASED PROSTHETIC JOINT

The present invention relates to an electrically released prosthetic joint such as a knee joint for an artificial leg and particularly to a so-called primary artificial leg that has an electrically operated release mechanism.

We have previously described and claimed in Patent Specification GB-A-2099708 a knee joint for an artificial leg that is of mechanically simple construction but is nevertheless durable and effective. It comprises a knee member having a part spherical convex lower surface pivoted about an axis to a knee housing having a part spherical concave upper surface conforming to that of the knee member. The knee member has a spring-loaded locking plunger posterior to the pivot axis and having a generally vertical line of action that as the knee is straightened from a flexed position is retracted as it travels over a rib upstanding from the curved top surface of the knee housing, until the fully unflexed position is reached, when the locking plunger latches into a seating or socket in the knee housing to prevent flexion of the joint.

It is an object of the invention to provide an electrically operated release mechanism for the knee joint aforesaid that can be operated reliably with economy of power and without undue power drain in the event of a failure to release. Although particularly intended for a knee joint, the present invention is also applicable to other kinds of prosthetic joints that are releaseably locked by engagement of a spring loaded plunger into a socket.

The invention therefore provides a joint for a prosthesis having first and second members pivoted together for relative angular movement and a spring loaded plunger in one member that latches into a socket in the other member to hold the members in one angular position, wherein a solenoid is operatively connected to the plunger so that energisation thereof unlatches the plunger from the socket, a sensor detects unlatching movement of the solenoid and a circuit responsive to actuation of an operating switch and to the sensor is arranged to reduce the current through the solenoid to a holding value if unlatching movement occurs within a set time after actuation of the operating switch and in the absence of movement within that time substantially de-energises the solenoid.

An embodiment of the invention will now be illustrated in the accompanying drawings in which:

Figure 1 shows in vertical section the region adjoining the knee of an artificial leg showing schematically an associated solenoid and control unit; and

Figure 2 is a circuit diagram of the solenoid and its associated parts.

In Figure 1 a thigh stump socket (not shown) is fixed to a knee member in the form of a shaped block 10 of wood, polyurethane foam or other conveniently worked material. The height of block 10 may be adjusted eg. by cutting with a saw to meet the needs of an individual patient for whom the limb is intended. A relatively large

vertical bore 13 from the top face of block 10 leads to a smaller bore 14 that opens through the lower face of the knee block which is part spherical at a position posterior of the position of knee bolt and bearings 12. An extension buffer 33 mounted on a plate 33a is let into the curved lower face of the knee member 10 below bolt 12 as viewed in Figure 1. The portion of the block 10 posterior of the extension buffer 33 is formed with a channel 11 or is otherwise relieved, and a plunger 18 in housing 16 is mounted in the bore 14 so that it has a vertical line of action and in its position of maximum downward extension the tip projects beyond the relieved portion of the block surface but not significantly beyond the envelope of curvature of the lower face of the block. By this means, as will become apparent below, the tip of the plunger cannot latch onto the top anterior edge of the knee socket and thereby accidentally lock the knee in a fully flexed or hyperflexed state. Plunger 18 is urged downwardly by coil spring 17 in housing 16, has bearing portions towards its upper and lower ends that slideably guide it in the housing for vertical movement and is directly connected at its upper end to Bowden cable 25 which may be pulled upwardly to release the joint. Plunger 18 has a conical tip provided with an anti-friction pip 22 of Teflon or like material.

The knee housing 30 may be a casting in light alloy or an injection moulding in glass filled nylon and is pivoted to the knee member by bolt 12. Its upper face presents a part spherical concave surface conforming generally to the curvature of the lower face of the knee member. It is supported on a pylon tube 32 to which it is connected by a demountable compression joint. The upper face of the housing 30 is formed with an upstanding rib 29 whose curved top face forms a smooth track leading to a spigot 31 also upstanding from the top face of the housing 30 at a posterior location. The track defined by rib 29 leads to a frustoconical seating or socket 34 into which

the tip of plunger 18 locates when the knee and shin portions of the leg are in the unflexed position shown. By this means the plunger and seating automatically take up wear so that the knee has no play in its unflexed locked state that would be damaging to patient confidence. The knee is locked both against flexion and against over-extension by the plunger 18. A solenoid 40 is secured in fixed position above the plunger 18 and has a moving element 41 connected to the cable 25 thereby directly to raise and disengage plunger 18 from socket 34 after which anti-friction pip 24 travels over the top face of rib 29 as the knee flexes, the said rib either supporting the retracted plunger and allowing it to extend gradually as the knee flexes.

The fully unflexed position of the knee is detected by a microswitch 42 in the knee member 10 that is tripped by the top anterior edge of knee housing 10. As the knee is returned from the flexed to the straight position the plunger 18 travels back over the top face of rib 29 by which it is retracted into the housing 16 and automatically latches back into the seating or socket 34. The extension buffer 33 and plate 33a are formed with a notch to accomodate the rib 29 as the knee is unflexed.

The solenoid 40 is powered from a battery 43 under the control of a control unit 44 and retraction of the plunger 18 is initiated by operation of an operating switch 45. The control unit 44 supplies current to a light-emitting diode 46 and responds to phototransistor 47 that together form an optical switch. It is arranged that the beam between diode 46 and transistor 47 is uninterrupted when the plunger 18 is home in the socket 34, but is interrupted when moving element 41 of the solenoid 40 has risen to unlatch the plunger 18, bringing blade on element 41 into the light path. Detection of unlatching is used to adjust the solenoid current as described more fully below and thereby prolong battery life. Also connected to control unit 44 is microswitch 42

that detects when the leg is unflexed. In a condition of slight leg flexion high lateral loads are imposed on plunger 18 and socket 34 thereby making it difficult to disengage the plunger 18 therefrom. Consequently control unit 44 is enabled to pass power to solenoid 40 only when the state of micro-switch 42 indicates that the leg is at its fully unflexed position.

Figure 2 shows those parts of the control circuit that pertain to the solenoid. The voltage V is applied across resistor R_1 of value typically 100 KΩ connected in series with capacitor C_1 and the junction therebetween is connected to input 2 of NAND gate 49, the input 1 being connected to the output of opto-switch 46, 47. The normal state of switch 42 is that it is connected to a 100Ω resistor R_2 across capacitor C_1 which is thereby discharged. On actuation of the switch 45 the capacitor C_1 is charged through R_1 and reaches a potential sufficient to influence the logic state of gate 49 after an appropriate time, typically one second. At power on the solenoid is down and the output from the optical switch is applied at input 1 logic 1 but the voltage from capacitor C_1 applied at input 2 is logic 0 and the output 3 is logic high and is fed through resistor R_3 to the base of transistor Tr_1 which then becomes conductive. Current flowing therethrough from the base of first power supply control transistor Tr_2 via resistor R_4 then causes Tr_2 which is normally non conductive by reason of high value biasing resistor R_5 to become conductive. Because the output of opto-switch 46, 47 is high, transistor Tr_3 and current flows via R_6 to the base of second power control resistor Tr_4 that is otherwise biased to a less conductive state by biasing resistor R_7. In consequence second power control transistor Tr_4 has maximum collector-emitter conductivity and series connected transistors Tr_2, Tr_4 pass about 2 amps to solenoid 40 which is sufficient to lift the plunger 18. If the plunger moves within the one second time constant of R_1, C_1, blade 48 interrupts the

light beam, the output of optical switch 46, 47 falls and transistor Tr_3 becomes non-conductive. The base of transistor Tr_4 is now biased conductive by resistor R_7. the logic values at inputs 1, 2 of gate 49 are both low, so the output at 3 remains logic high and transistors Tr_1, Tr_2 remains conductive. Therefore transistors Tr_2, Tr_4 pass a holding current of about 300 mA to the solenoid 40 which is sufficient to maintain the plunger 18 retracted. If however the plunger 18 does not move within the time constant of R_1, C_1 the inputs 1, 2 to gate 49 both become logic 1 and the output at 3 becomes logic 0, thereby rendering transistors Tr_1 and Tr_2 non-conductive. The only current through solenoid 40 is then from transistor Tr_3 via the base of Tr_4 which is insufficient to bring about rapid discharge of battery 43. It will therefore be appreciated that effective operation of solenoid 40 is brought about with maximum battery power economy.

It will be appreciated that various modifications may be made to the embodiment described above without departing from the invention, the scope of which is defined in the appended claims.

CLAIMS:

1. A joint for a prosthesis having first and second members (10, 30) pivoted together for relative angular movement and a spring loaded plunger (18) in one member (10) that latches into a socket (34) in the other member (30) to hold the members (10, 30) in one angular position, characterised in that a solenoid (40) is operatively connected to the plunger (18) so that energisation thereof unlatches the plunger (18) from the socket (34), a sensor (46, 47) detects unlatching movement of the solenoid (40) and a circuit (44) responsive to actuation of an operating switch (45) and to the sensor (46, 47) is arranged to reduce the current through the solenoid (40) to a holding value if unlatching movement occurs within a set time after actuation of the operating switch (45) and in the absence of movement within that time substantially de-energises the solenoid (40).

2. A joint according to Claim 1 wherein the solenoid (40) is mounted at a fixed spacing from the plunger (18) and is connected to one end of a Bowden cable (25) whose other end is connected to the plunger (18).

3. A joint according to Claim 1 or 2, wherein the sensor is an optical source (46) and detector (47), light transmission therebetween being altered as a moving element (48) of the solenoid is displaced from the plunger latched position.

4. A joint according to Claim 3, wherein the optical detector output is fed to a first input of a logic gate (49) whose second input is controlled by a capacitor and resistor (C_1, R_1) that determines the set time and the output of the logic gate is fed to the base of a switching transistor (Tr_1) that controls the base of a first power supply control transistor (Tr_2) whose collector and emitter provide the current path to the solenoid (40), the said path being conductive when the output of the gate (49) is in one logic state only.

5. A joint according to claim 4 wherein the current path

to the solenoid (40) is between collector and emitter of a second series connected power supply control transistor (Tr_3) whose base is switched between first and second bias states depending on the state of the optical switch (46, 47), so as to give the high solenoid current when the plunger (18) is latched and the lesser holding current when the solenoid (40) is unlatched.

6. A joint according to any preceding claim, further comprising a switch (42) responsive when said members (10, 30) are in said one angular position and said circuit (44) responds to the state of said switch (42) to enable power supply to said solenoid (40) only when said members (10, 30) are in said one angular position.

7. A joint according to any preceding claim which is a knee joint for an artificial leg comprising a knee member (10) having a part spherical convex lower surface pivoted about an axis (12), a knee housing (30) having a part spherical concave upper surface conforming to that of the knee member, the knee member (10) having the locking plunger (18) located posterior to the pivot axis and having a generally vertical line of action which as the joint is straightened from a flexed position travels over a rib (29) upstanding from the upper surface of the knee housing by which it is retracted and when the unflexed position has been reached is urged by a spring (17) into latching engagement with the socket (34) which is in the knee housing (30) to prevent flexion of the knee.

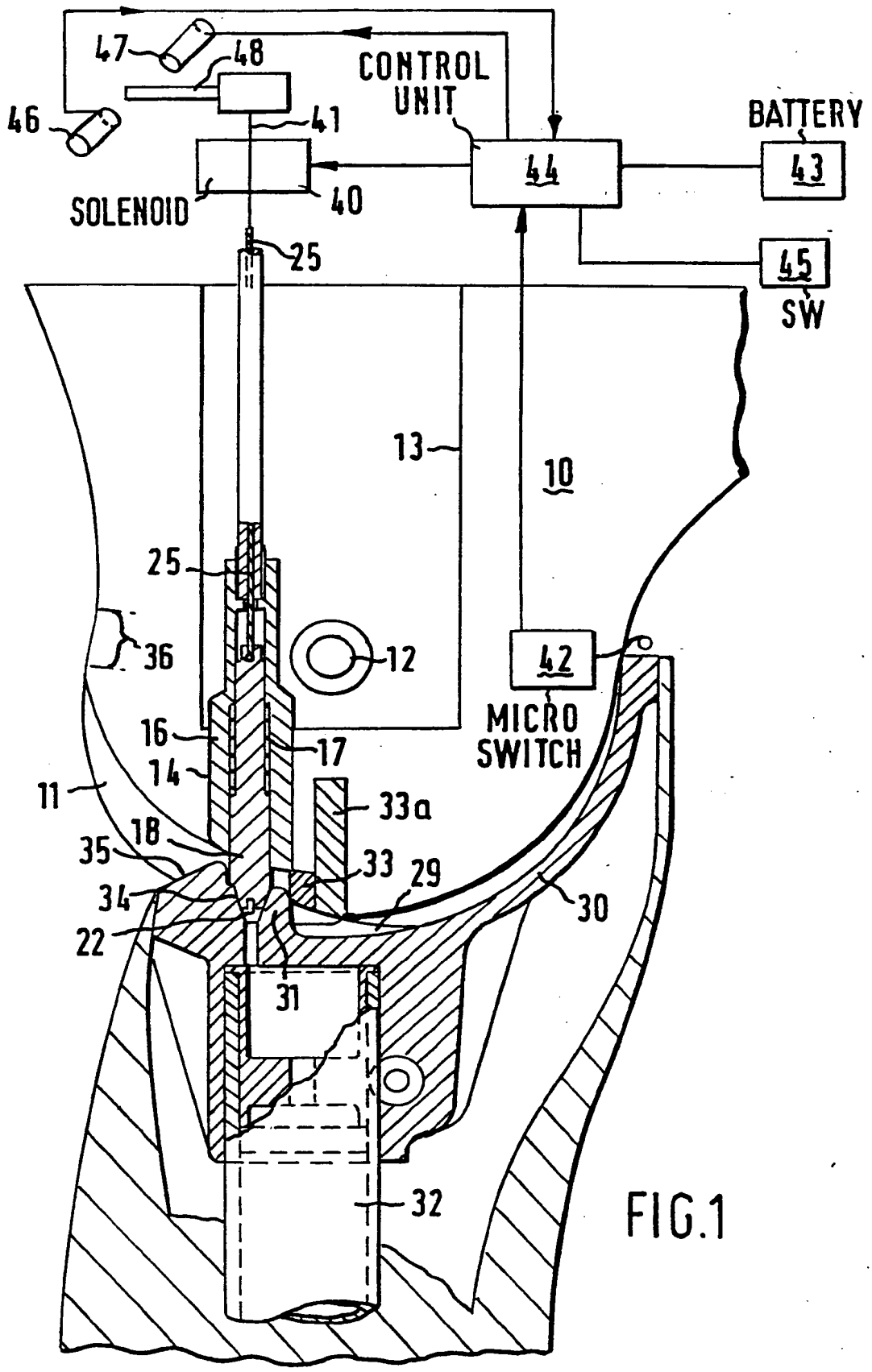


FIG.1

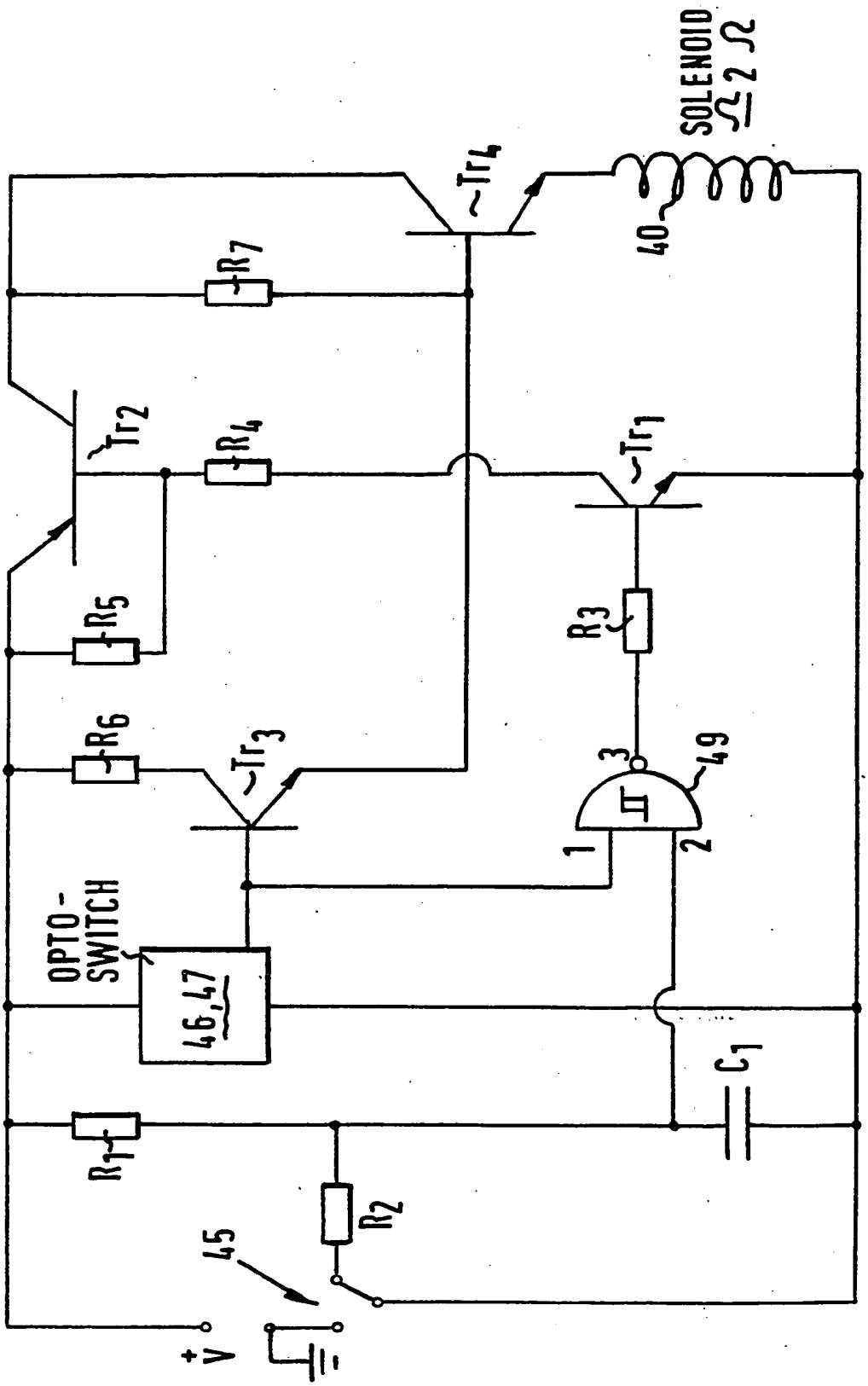


FIG.2

8520

0141640

Application number

EP 84 30 7463

European Patent Office

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-1 585 256 (COLLINS) * Page 2, lines 94-130; page 3, lines 1-56; figure 3; claim 1 *	1	A 61 F 2/60
A		2-6	

Y	US-A-4 074 367 (LOVELESS) * Figures 1,3; column 2, lines 43-68; column 3, lines 1-16, lines 39-68; column 4, lines 1-46 *	1	

A	GB-A-2 099 708 (HANGAR) * Whole document *	2,7	
	-----		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			A 61 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14-02-1985	LOWE D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503 03.82